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Anterior Approach to Total Hip Replacement: Surgical Technique and Clinical Results of Our First One Thousand Cases Using Non-Cemented Prostheses

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Total hip replacement has evolved into one of the most frequently performed reconstructive procedures in orthopaedic surgery today. A modified anterior approach developed by the senior surgeon has been utilized in performing over 3,000 operations in the past two decades. It is a unique and facile exposure. It can be easily applied to primary and revision surgery. Noncemented prostheses have been used in over 1,000 of these operations. This article details the surgical exposure, acetabular and femoral preparation for both non-cemented and cemented prostheses, special considerations for revision surgery, and the clinical results of the experience with noncemented prostheses to date.

INTRODUCTION

THR[e] was popularized by Charnley in 1961 [1]. It has become one of the most frequently performed and most successful reconstructive procedures in orthopaedic surgery over the past three decades. It is estimated that nearly 200,000 cases are currently performed in the United States each year. Surgical techniques and implant designs have evolved tremendously since this operation was first developed. The purpose of this article is to describe the surgical technique that has been developed and perfected by the senior surgeon over the past 20 years [2]. This approach has been used in performing nearly 3,000 THR's both of the primary and revision type. We specifically present in this article the clinical results of the first 1,000 consecutive cases using non-cemented prostheses performed over the past decade.

GENERAL SURGICAL PRINCIPLES

Numerous anterior, anterolateral, lateral, and posterior approaches have been described for various hip arthroplasty procedures [3, 4]. Advocates of anterior approaches to the hip have included Smith-Petersen [5], Bost and colleagues [6], Cubbins and associates [7], Sutherland and Rowe [8], Fahey [9], and Luck [10].

The anterior approach in our series of patients employs a curved transverse skin incision. As the anterior border of the tensor fascia lata muscle is exposed, a distally and medially based skin flap is created. By longitudinally splitting the fibers of the anterior border of the tensor fascia lata muscle, the anterior capsule of the hip is directly exposed.

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[e]*Abbreviations used:* THR, total hip replacement.

The two principal elements of the approach are the noncongruent skin incision, and the muscle interval of dissection. The skin incision is similar to the proximal portion of a Watson-Jones approach [11], although it is begun directly distal (rather than distally and laterally) to the anterior superior iliac spine. The muscle interval is logical since it is between the tensor fascia lata, a muscle confluent with the fascia lata which inserts laterally, and the sartorius muscle which takes origin at the anterior superior iliac spine and inserts distally into the medial proximal tibia. As Lowell and Aufranc [12] have pointed out, the dissection passes through an "internervous line." The muscle retracted medially is innervated by the femoral nerve and upper lumbar root, whereas the muscles retracted laterally are innervated by the superior gluteal nerve. The Smith-Petersen approach expands this interval by freeing from the iliac crest the origins of both the gluteus medius, minimus, and tensor fascia lata muscles.

PRE-OPERATIVE PREPARATION

Several days prior to surgery, our patients undergo pre-operative testing on an outpatient basis. These studies include a chest x-ray; repeat films of the hip, proximal femur, and pelvis; electrocardiogram; a complete blood count; electrolytes; coagulation parameters (prothrombin time, partial thromboplastin time); and a urinalysis. All patients in good medical condition have also given three units of autologous blood in preparation for transfusion needs in the course of surgery. We feel it is extremely important to admit the THR patient to the hospital one day prior to surgery. On this day and night prior to surgery, the patient is seen by the anesthesiologist, an internist, the operating surgeon and his resident, and the nursing staff. The operative plan is reviewed with the patient and the surgical team. Adjustments in medications can be made. Additional consultations can be obtained, and other social or emotional problems can be addressed. The progression from admission to the operating room is orderly and methodical.

The skin preparation is also started on the night prior to surgery. The patient is shaven from the chest to the toes on the operative side. The same area is scrubbed with Betadine scrub immediately after the shave, and again on the morning of surgery. Following the second scrub, the skin is washed and dried, and then painted with Betadine solution. This solution is allowed to dry on the skin. In the operating room, another layer of Betadine solution is applied from the chest to the toes using an aerosol spray method. This skin preparation has been in use for most of our 3,000 THR patients. The only exceptions have been patients with iodine allergies. Their skin preparation has been a Phisohex scrub the pre-operative night and again in the operating room.

ANTIBIOTIC COVERAGE

With minor modifications, the prophylactic antibiotic coverage for routine cases has been with intravenous cephalosporins just prior to surgery, during surgery, and for 48 hrs after surgery. Following the first 48 hrs of intravenous antibiotics, we have continued our patients on oral cephalosporins for another 48 hrs. At the current time, our intravenous antibiotic of choice is cephalothin (Cephadyl, Bristol, Evansville, IN), and the oral medication cefadroxil (Duricef, Mead Johnson, Evansville, IN). All operations are performed in clean-air operating suites without laminar air flow system. However, no body-exhaust suits are worn by the surgical staff.

BLOOD TRANSFUSION

By using the patient's own blood (3 units) obtained and stored prior to surgery, by using a cell saver during the operation, and by collecting and reinfusing drainage blood during the post-operative phase, it has been possible to perform almost all of our simple and primary THRs without donor blood.

ANESTHESIA

All operations are routinely performed under normotensive general anesthesia.

Central venous monitoring and arterial lines are used only if the patient has significant pre-existing cardiopulmonary pathology.

SURGICAL METHOD

Positioning

To aid in orientation, the operating table is placed parallel to walls of the surgical suite. The patient is positioned with the axis of the pelvis at right angle to the long axis of the table. The uninvolved leg is abducted and placed on a board extending beyond the edge of the operating table. This allows for better adduction of the operated leg should such be needed for better exposure of the proximal femur. A small sand bag is placed under the patient's sacrum and lumbar spine. This tilts the pelvis forward, allows better draping of the hip, and makes femoral access easier since it places the femur in slight extension especially after the femoral neck has been cut. Femoral extension and exposure can be increased by lowering the foot of the operating table. This is necessary only on rare occasions but may help in some difficult femoral exposures. The hip and leg are then draped free. An ace compression bandage is wrapped around the foot and leg up to the proximal thigh. This compresses the superficial veins and minimizes venous pooling. It also shows the contours of the leg. The position of the patient is anatomical; thus, the orientation of the components, both acetabular and femoral, can be achieved in an anatomical fashion.

Surgical exposure

A curved incision is made from a point just distal to the anterior superior iliac spine to the anterior border of the greater trochanter. The acetabulum could be exposed through a straight longitudinal incision extending from the iliac spine distally, however this incision does not allow access to the proximal femur. In order to rasp and prepare the proximal femur, a slight curve in the incision is necessary.

After the anterior medial skin and subcutaneous fat have been dissected and retracted medially, the tensor fascia lata muscle comes into view. The fascia and the tensor fascia lata muscle are split longitudinally in the direction of the muscle fibers approximately one centimeter lateral to the medial border of the muscle. By preserving a medial strip of fascia and fascia lata muscle, the branches of the lateral femoral cutaneous nerve are protected.

As soon as the tensor fascia lata muscle has been split, the underlying anterior hip capsule can be visualized. The exposure of this structure is facilitated by placing cobra retractors on the superior and inferior aspects of the capsule and the underlying femoral neck. As the muscle is split and spread, the anterior femoral circumflex vessels come into view. They course at 90° to the longitudinal fibers of the tensor fascia lata muscle and are located one to two centimeters distal to the hip capsule. They are easily visualized, cauterized, and transected. Occasionally, one of the arteries is large enough to require ligation or clipping.

The anterior capsule can be covered by some loose fatty tissue. If this fat obstructs the visualization of the capsule, it can be removed with a rongeur. Once the anterior hip capsule is identified, it is excised as completely as possible to expose the femoral neck. Some minor arterial bleeders may be encountered but these are easily controlled by electrocoagulation.

Femoral neck osteotomy

Once the femoral neck has been exposed, it is osteotomized at an angle and level predetermined by the configuration and the collar of the prosthesis to be used. Several of the total hip system instruments we have used have had devices to facilitate the exact placement of the osteotomy; however, due to the anatomical position of the femur and the excellent visualization of the femoral neck, we have rarely used them. We draw the line of the osteotomy cut on the pre-operative roentgenogram, and by having this film with its projected osteotomy line in view during the operation, we have routinely been able to reproduce it *in vivo*.

During our early experience with this approach, we used osteotomes to transect the femoral neck. The incidence of trochanteric and calcar fractures was unacceptable, and we have switched to using an oscillating saw.

The femoral head is removed with a hip skid and/or a cork-screw device. In cases of extremely severe arthritis or ankylosis, the femoral head is morcellized and removed with osteotomes and large curettes.

Acetabular exposure and preparation

After removal of the femoral head, the remaining capsule is excised. If necessary, a total capsulectomy is performed. A cobra retractor is placed on the lateral ilium. This allows lateral retraction of the tensor fascia lata and abductor muscles. Another cobra retractor with a sharp point is placed behind the medial rim of the acetabulum. This retracts the medial structures. The point of this retractor is usually at 5 o'clock on the right hip and 7 o'clock on the left. Once the acetabulum has been exposed, the ligamentum teres, its remnant and fat pad are removed with a curette and rongeurs. The transverse acetabular ligament is also excised, since it may interfere with adequate medial placement of the acetabular reamers and the acetabular prosthesis. The artery of the ligamentum teres may have to be cauterized. If large medial inferior osteophytes that block acetabular reaming are encountered, they, too, are removed at this time.

The acetabulum is reamed sequentially starting with reamers as small as 44 mm in diameter. This smaller reamer is used primarily to remove the osteoarthritic debris that have thickened the medial acetabular wall and to place the dome of the newly shaped acetabulum as far medially as possible. The direction of reaming is usually at 35° to 40° to the horizontal axis of the pelvis. Anteversion or flexion of the acetabular reaming is at 15° to 20°. The reamers must be directed and pushed medially and posteriorly to avoid damage to the lateral and anterior acetabulum. This is of greatest importance in those patients with shallow or dysplastic acetabuli. The reamers we use are of the basket type. They collect all the reamed bone chips, leaving the operative field clean of bony material that could lead to heterotopic bone formation.

Non-cemented cups

Even through we have used screw-in threaded cups of both the truncated cone and hemispherical type with great success, the non-cemented cup of our choice at this time is a hemispherical titanium-alloy cup porous-coated with beads. It is pressed-fit into the reamed acetabulum. The cup provides screw holes in its dome for additional fixation if necessary. In most patients we under-ream the acetabulum by 2 mm. Thus, the diameter of the reamed acetabulum is 2 mm smaller than the diameter of the prosthetic cup to be used. The slight elasticity of the cancellous bone allows for the impaction and solid mechanical fixation of the implant. This under-reaming and the relatively horizontal cup position achieve very stable cup fixation. Even though it may not be necessary, we use one screw as extra security to hold the acetabular shell and to provide added rotational stability. This screw is passed into the ilium through one of the holes just lateral to the dome of the implant. The length of this screw is 30 or 35 mm. If the underlying subchondral bone is very soft, or if there is concern about the acetabular stability due to such factors as inadequate peripheral coverage, more than one screw can be used. This is rarely necessary in routine primary cases. In revision surgery, it may be necessary to use more than one screw through the dome of the acetabulum and to choose an acetabular component that also allows for screw fixation along the peripheral acetabulum. In general, we rely on the press fit obtained by under-reaming the acetabulum and the horizontal cup position we seek to maximize stability of the cup.

Cemented cups

For cemented acetabular components, the shaping and reaming of the acetabular bone is the same as in cementless devices. We medialize as much as possible, and prefer a horizontal position. We over-ream the acetabulum by 1 or 2 mm in order to create an even cement mantle between the cup and bone. Once the acetabulum has been reamed, we create multiple anchoring holes for the cement with a blunt round Jewett punch of 6-millimeter diameter. These punched holes are dead-end "cul-de-sac" from compaction of the cancellous bone at the ends of the holes. These allow for better cement pressurization and fixation to bone. By punching rather that drilling the bone, loose bone chips are avoided and there is a saving in time. We routinely make five to six holes in the acetabular dome, three to four along the posterior wall, one to two in the ischium, and one in the pubis. The thin central medial portion of the bony acetabulum is avoided. If perforations occur, they are packed with cancellous bone obtained from the excised femoral head, or from the intertrochanteric region of the femur which is easily accessible.

Following creating these multiple anchoring holes, the acetabulum is irrigated and dried with hydrogen peroxide. We have been pleased with and continue to use Palacos bone cement (Richards, Memphis, TN). It is pressed into the acetabulum and the anchoring holes in its doughy state by digital pressurization. The acetabular prosthesis is then placed into the mass of cement and pushed into position. As in the case of cementless prostheses, we seek a relatively horizontal position with approximately 15° to 20° of anteversion. Once this position has been achieved, the acetabular cup is held firmly until the cement solidifies. Our preferred cemented acetabular prosthesis is an all-polyethylene cup with methylmethacrylate pods for an even cement mantle and a peripheral overhang that helps to push and pressurize cement in the bony acetabulum. This design also allows for maximal polyethylene thickness to minimize wear and osteolysis in the long term.

Femoral exposure and preparation

With the acetabular prosthesis in place, the leg is externally rotated. With the slight leg extension allowed by the sand bag under the sacrum, the proximal femur is partially visualized. By using a bone hook under the lesser trochanter the femur is pulled up into an accessible position. Care must be taken not to perforate the femur with the bone hook. If the tip of the hook is in the medullary canal, it may misguide the femoral reamers and rasps and cause major perforations or fractures. It may also lead to malpositioning of the femoral component. These events are obviously more likely in patients with osteoporosis. Even though we apply a great deal of force through the bone hook under the lesser trochanter, we have not had any femoral fractures, trochanteric avulsions, or iliopsoas tendon tears from this maneuver.

If simple bone hook traction does not allow adequate instrumentation of the femur, further soft tissue releases must be done. The simplest of these is the release of the tensor fascia lata muscle origin from the anterior 3 to 5 cm of the iliac crest. Transection of the inferior medial portion of the hip capsule is also easily performed after a blunt dissection of the interval between it and the adjacent (sometimes adherent) iliopsoas tendon has been done. The capsule is cut with scissors close to its insertion on the femur. It is an area that is relatively bloodless and its release, if indicated for femoral mobilization, can be of great help. Next, if necessary, a release of the remnants of the posterior superior hip capsule, the short external rotators, and the piriformis muscle can be performed.

The posterior capsular release is accomplished by placing the leg in maximal external rotation, and the proximal femur pulled up into the wound by means of the bone hook. The release is done with a scalpel. The capsule and tendons of the obturators and piriformis are cut at their insertion on the greater trochanter and the intertrochanteric crest. As these tendons are released, an attempt is made to identify and control the posterior circumflex vessels before they retract into the deeper portions of the wound. If that occurs, a complete release of the posterior capsule, tendons and piriformis is performed and the proximal femur is pulled distally and laterally by means of the bone hook. This usually allows adequate visualization of the bleeding vessels which are then clamped and cauterized.

If the exposure of the proximal femur is extremely difficult, a fold-back osteotomy of the greater trochanter is performed. The osteotomy is performed from anterior to posterior with the longitudinal axis of the osteotomy being in line with the lateral femoral shaft [13]. The hip abductors and the vastus lateralis are left in continuity on the greater trochanter. This confers dynamic stability to the trochanteric fragment. The stability of the trochanter is further enhanced by maximal preservation of the periosteum and muscles along the posterior portion of the osteotomy. The greater trochanter is folded laterally and the proximal femoral canal is visualized for instrumentation or cement removal in cases of revision surgery. At the end of the operation, the trochanter is folded back into its anatomical position, and fixed with two or three bone sutures of heavy nylon, or with wires passed through the anterior cortices of the trochanter and proximal femur.

If at all possible, we have avoided iliopsoas tenotomies. In cases that additional anterior soft tissue release is necessary, such as in congenital dislocations, we have favored a z-plasty lengthening of the iliopsoas tendon rather than a complete transection.

Non-cemented stems

Once the proximal femur has been adequately exposed, it is prepared for the insertion of the femoral component. The intertrochanteric area is penetrated with a curette, and the remaining superior lateral cortex of the femoral neck is removed with a rongeur or a box osteotome. This is done to facilitate femoral rasping and reaming in the long axis of the shaft. Occasionally it is even necessary to cut into the greater trochanter itself to maximize lateralization. If the lateral cortex and the base of the greater trochanter are not notched and prepared in this manner, rasping of the femoral canal becomes much more difficult, lateral femoral cortical perforations more common, and improper varus positioning of the femoral component may be unavoidable.

For the precise longitudinal reaming of the femoral canal in press fit non-cemented prostheses, a separate stab wound is made in the skin proximal to the greater trochanter. The underlying gluteus maximus muscle is split along its fibers. Through this stab wound the appropriate cylindrical canal reamers are passed for femoral reaming as far distally as necessary. This technique is similar to that utilized for close femoral nailing.

The rasping of the proximal femur is done in a sequential manner starting with the smallest rasp and progressing to the largest rasp that the femur will accept. The handle of our rasps is designed at approximately 45° to the long axis of the rasp itself. This angulation allows easy penetration of the proximal femoral canal. Most of the instrument systems provide straight-handle rasps. Preparation of the femur using these rasps would be more difficult. Modification of the handle can be easily done, and provided by the manufacturers.

Proper pre-operative templating facilitates the sizing of the component. In non-cemented devices, the rasp is slightly smaller than the corresponding prosthetic stem to assure maximum fixation and the most stable fit. In cemented prostheses, the stem is smaller than the rasp to assure an adequate cement mantle around the stem.

After the femoral canal has been rasped to the appropriate size of the cemented prosthesis, a trial prosthesis is inserted. The proper femoral head is selected, and a trial reduction is performed. The length of the femoral neck (head) is determined primarily by the intrinsic stability of the hip, and soft tissue tension (abductors, iliopsoas, rectus femoris). Leg length is assessed by palpation of the anterior iliac spine, the patella, and the medial malleoli. These measurements are easily compared to the contralateral leg which is readily accessible. It is also possible to palpate the lesser trochanter of the femur and its relationship to the ischium. By comparing these findings to the pre-operative roentgenograms, major errors can be avoided. In over 95% of our cases, the leg lengths are equal. Unfortunately, there are times that for the sake of stability, it is necessary to accept a slightly longer leg length. The patient's spine, pelvis and other major joints usually adjust to this leg length discrepancy, but on occasion a shoe lift on the opposite side may be necessary. Some of the leg length and stability problems can be helped by the selection of a prosthesis with greater offset, but most patients tolerate nicely the less than perfect anatomical offsets and slight leg length discrepancies.

We have used a variety of non-cemented and cemented stems. At the present time, our preference is for a non-cemented stem made of titanium-alloy, and a cemented stem made of cobolt-chrome alloy. We have used a variety of stem configurations. At the present time, our preference is for a straight stem with a collar that rests on the calcar adding stability to prosthetic fixation. The seating of the prosthesis on the calcar must, however, be very tight in non-cemented cases. The prosthesis must be driven down to the calcar. If it slips loosely into the femoral canal and comes to rest without any force on the calcar, the femoral component will not be properly fixed. The fixation of the prosthesis must be achieved by maximizing fixation stability within the femoral canal at the time of surgery. The collar-calcar seating completes the fixation. It should not be the sole fixation. It is of note, however, that we have been getting excellent results with the collarless non-cemented prosthesis of the Optifix type (Richards, Memphis, TN), and more recently with the collarless HJD system (Richards).

Cemented stems

We have used a variety of bone cement since our first THR in 1970. We have vented our femoral shafts with drill holes. We have plugged them with bone, cobalt-chrome, methylmethacrylate, silicone, and polyethylene restrictors. We have used distal centralizers on the femoral stems. We have injected the cement using a gun in a retrograde fashion. We have used cement of low viscosity. At the present time, we are satisfied with finger packing and pressurization of Palacos cement.

Once the femoral component size and neck length have been determined by the trial prosthesis, the femoral canal is prepared for the cement. The canal is irrigated with saline. Some of the intramedullary debris is removed by this process. A suction tampon soaked in hydrogen peroxide is then inserted into the medullary canal. The hydrogen peroxide has a drying effect and because of the suction on the tampon, more bone debris is removed when the tampon is pulled out slowly from the femoral canal. A number 16-gauge rubber catheter is inserted into the femoral canal and attached to suction. It evacuates blood, fat, and any monomer that may be escaping. It also sucks down the methylmethacrylate mass into the femoral canal.

Palacos cement is of high viscosity, and its mass does not shrink as it sets. It is inserted in a doughy phase. A cylindrical mass of Palacos is easily guided into the femur and slides down assisted by gentle pressure proximally and the negative pressure created by the suction catheter in the canal. After the cylinder of methylmethacrylate has been inserted, it is pushed distally by finger. The proximal portion of the femur is fully packed and pressurized by finger. Once the proximal femur has been packed with the cement, the selected permanent femoral component is inserted. It is kept in neutral rotation, and as close to neutral as possible for the longitudinal orientation. The doughy high viscosity Palacos cement is not pushed nor does it flow down the femoral canal. The distal portion of the cement acts as a plug, and as the femoral component is inserted into the mass of cement, it expands circumferentially into the surrounding walls of the femur. The femoral component is then held still until complete setting of the cement has occurred.

Wound closure

The wound is irrigated and debrided. All bleeders (especially the anterior circumflex vessels) are once more inspected and cauterized if necessary. After a clear, dry operative field has been obtained, the hip is reduced, and its range of motion and stability are checked. A suction drain is placed along the posterior aspect of the hip in the deeper, dependent portion of the wound. The wound is then closed. Since the incision has been of the muscle splitting type, the closure requires only one continuous chromic suture to approximate the tensor fascia lata. A few chromic sutures are used for the deep fibrous subcutaneous fascia. Interrupted plain catgut sutures are used for the subcutaneous fat, and surgical staples for the skin.

Postoperative care

Postoperatively, both our non-cemented and cemented total hip patients are managed the same way. Ambulation is started on the first post-operative day. Weight bearing is allowed as tolerated and, most all leave the hospital walking with a single cane on the sixth or seventh postoperative day.

Revision of failed THR's

We approach failed THR's through the same anterior approach. It has the advantage of not having the major arteries and nerves in the operative field. Once the tensor fascia lata and the fascia itself have been split as in a primary procedure, it is possible to identify the mass of scar tissue that surrounds the acetabulum, femoral neck, and proximal femur. Localization of the hip and this scar tissue can be facilitated by palpation of the lesser trochanter and dissection of the iliopsoas tendon. Once this has been done, the scar tissue is exposed by means of cobra retractors placed in a manner similar to that used in primary procedures. The lateral-superior cobra retracts the tensor fascia lata muscle and the abductors. The medial-inferior cobra with its tip between the iliopsoas and the periarticular scar tissue, retracts the medial sartorius, rectus femoris, and iliopsoas. It also protects the femoral artery and nerve.

Once the scar tissue has been exposed, it is excised to expose the femoral and acetabular prostheses. Frequently, this tissue is so hard that an osteotome has to be used to transect and excise it. An osteotome is also useful in the transection of tight, dense scar tissue in the deeper posterior portion of the wound. Rotation, adduction, and abduction in various combinations would give access to these posterior tissues. Care must be taken not to dissect too deeply. However, the sciatic nerve is medial to the femoral neck area, and the dissection can proceed with relative safety.

As soon as feasible after this scar tissue excision and transection, the femoral component is dislocated from the acetabulum and removed from the medullary canal. Once this has been accomplished, exposure and excision of the remaining granulation tissue becomes much easier. The acetabular component is removed after adequate exposure has been obtained. The acetabular fossa is then debrided. Revision of the cup is performed first, following the same surgical principles outlined previously.

The femur is then mobilized by release of all scar tissues. Occasionally, it is necessary to expose the femoral shaft more distally for such procedures as an osteotomy, or the fixation of fractures and perforations. The skin incision is extended distally along the lateral aspect of the thigh. The fascia lata split is extended, and the vastus lateralis is split longitudinally with subperiosteal dissection for access to the femoral shaft. Soft-tissue dissection is generally kept at a minimum to retain adequate vascular supply to the femoral shaft. Through this approach, we have been able to adequately address all types of revisions, osteotomies, femoral shaft windows, bone grafting, and fracture fixation.

Femoral revision is performed almost exclusively by using non-cemented prostheses. We believe these implants will allow for the best long-term fixation stability in these difficult cases. The principle of achieving maximal fit and fill, along with rotational stability at the time of surgery must be carefully followed, as they have been detailed previously.

Non-cemented THP

THR using non-cemented prostheses has become increasingly popular over the past decade. It has become an acceptable alternative to cemented THR especially in younger, more active, and obese patients. It is theorized that these prostheses will eventually achieve stable biologic fixation which will be more durable than cement fixation. These implants may be especially superior to cement fixation in revision situations.

The senior surgeon began implanting non-cemented prostheses in January, 1983. To date, 687 primary THR's and 313 revision THR's have been performed using non-cemented prostheses. It is beyond the scope of this article to detail the clinical and radiographic results of all the cases. We will specifically present some of the important features associated with the surgical techniques outlined previously.

Eleven different prosthetic systems have been used over the 10-year interval. They are outlined in Table 1. This is a spectrum of implant systems including prostheses of a simple mechanical design without biological fixation, and prostheses with surfaces designed to achieve biological fixation of the prostheses by bony ingrowth into metallic beads or mesh on the surface of the implant.

Some prosthetic systems required sequential reaming using cylindrical reamers (60% of the stems) which necessitated tunneling through a proximal stab wound. Some required only sequential rasping and broaching (40% of the stems). Threaded cups were used in approximately 35% of the hips, while semi-circular porous-coated cups supplemented with screw fixation were used in 65%.

Unilateral primary THR's were performed in 493 patients, bilateral THR's in 97 patients (194 hips), and revision THR's in 313 patients. There were 529 men and 364 women. The average age for these patients was 58 yrs (range 12 to 82 yrs). The average height and weight were 170 cm and 80 kg, respectively. Diagnosis in the primary group included: osteoarthritis in 430, avascular necrosis in 58, congenital dislocation of the hip (CDH) in 35, post-traumatic arthritis in 31, rheumatoid arthritis in 16, and others in 20. Revision of previously cemented prostheses was performed in 229 patients, while revision of a previous non-cemented prosthesis was performed in 53, and revision of a previous surface replacement was performed in 31 patients.

The average operating time for the entire group was 88 min (range 35 to 330 min). The average time for primary surgery was 71 min (range 35 to 180), while it was 132 min for revision cases (range 40 to 330). The average intraoperative blood transfusion was 1.8 units, with the average being 1.6 units for primary surgery and 2 units for revision cases. The average postoperative transfusion requirement was 1.6 units, with an average of 1.4 units for primary surgery and 2.1 units for revision cases. The average length of hospital stay was 8.3 days, including the pre-operative evaluation day.

Intra-operative and peri-operative complications were low in our patients. Intra-operative complications occured in 20 hips during primary surgery (3%). These are outlined in Table 2. Ten of these complications (50%) occured in our earliest experience with the Mittlemeir system which provided no power cylindrical reaming instrumentation, and only offered a limited inventory of prostheses. Three other cases involved complex reconstructions in CDH, and femoral malunion due to previous trauma.

Post-operative complications occured in 41 cases (5.9%) following primary surgery. They are outlined in Table 3. Seven dislocations occured in overly obese patients who had difficulty in physiotherapy. Five additional dislocations occured in complex reconstructions, and three in patients with poor mental status post-operatively who could not follow physiotherapy instructions well. Five patients developed post-operative wound hematoma while receiving heparin, one of which resulted in a transient femoral nerve palsy which resolved completely. Three additional nerve palsies occured in complex reconstructions of CDH.

Complication rate was greater in the revision patients as other series have also demonstrated. Intra-operative complications occured in 27% of the hips (Table 4). Of these complications, 62% occured during cement and stem removal. Post-operative complications occured in 8.7% of the cases (Table 5). These data are comparable to large

Table 1. Non-cemented THR prostheses used during primary and revision surgery.

Implant Selection			
Prosthesis	Primary	Revision	Total
Mittlemeir Ceramic System	184	77	261
Collared Optifix System	123	11	134
S-Rom System	25	102	127
Whiteside System	86	38	124
Zweymueller System	88	36	124
Collarless Optifix System	72	12	84
Triwedge System	46	10	56
Biofit System	16	16	32
Anatomic System	27	3	30
Gemini System	14	3	17
Harris-Galante System	6	5	11

Mittlemeir system (Osteo, Switzerland)
Optifix, Triwedge, Biofit systems (Richards, Memphis, TN)
S-ROM System (Joint Medical Products, Stamford, CT)
Whiteside system (Dow Corning, Memphis, TN)
Zweymueller system (Allopro, Switzerland)
Anatomic and Harris-Galante system (Zimmer, Warsaw, IN)
Gemini system (DePuy, Warsaw, IN)

Table 2. Intra-operative complications that occured during primary THR.

Primary Surgery		
Intraoperative complications	Hips	
Calcar Fracture	10	1.5%
Significant Greater Trochanter Fracture	5	0.7%
Proximal Femoral Shaft Fracture	5	0.7%

series of revision THR performed using cement published in the past decade by Callaghan et al. [25], Kavanagh et al. [26], and Pellicci et al. [27].(Table 6). In fact, our data are generally superior to the earlier reports. This is a reflection of the accessibility using this approach, and in part to the availability of power instrumentation.

DISCUSSION

Various surgical approaches for THR have been advocated on the basis of excellent exposure while minimizing soft tissue dissection and post-operative morbidity. Charnley

Table 3. Post-operative complications that occured following primary THR.

Primary Surgery		
Post-operative complications	Hips	
Dislocation	17	2.5%
Wound Hematoma	13	1.9%
Thromboembolic Disease	5	0.7%
Partial Nerve Palsy	5	0.7%
Deep Infection	1	0.2%

Table 4. Intra-operative complications that occured during revision THR.

Revision Surgery		
Intra-operative complications	Hips	
Perforations	24	7.7%
Fracture of the Greater Trochanter	24	7.7%
Fracture of the Calcar	21	6.7%
Fracture of the Proximal Femoral Shaft	16	5.5%

Table 5. Post-operative complications that occured following revision THR.

Revision Surgery		
Post-operative complications	Hips	
Hematoma	9	2.9%
Dislocation	8	2.6%
Infection	4	1.3%
Thromboembolic	4	1.35
Partial Sciatic Nerve Palsey	2	0.6%

Table 6. Complications in three reported large series of revision THR.

	Callaghan	Kavanagh	Pellicci
Number of Hips	139	162	99
Femoral Fracture/Perforation	17.1%	13.0%	15.5%
Infection	3.6%	1.2%	4.5%
Dislocation	8.2%	9.0%	3.6%
Trochanter Complications	6.2%	13.1%	12.7%

originally specified the transtrochanteric approach (osteotomy of the greater trochanter) when THR was first introduced and popularized three decades ago. This extensive approach is only rarely used today during revision surgery and complex primary procedures. Currently, the most frequently used techinque is the posterolateral approach which essentially involves splitting the gluteus maximus, and release of the short external rotators (piriformis, the gemilli, and the obturators). Another popular technique is the anterolateral approach which involves splitting the interval between the tensor faciae lata and the gluteus medius. It is often performed with partial release of the anterior fibers of the gluteus medius from the greater trochanter to facilitate exposure.

Few reports are available in comparing the different surgical approaches in THR. Vicar and Coleman compared the anterolateral, transtrochanteric, and posterior approaches in 269 primary THR's using cement [14]. They reported 9.5% dislocation rate using the posterior approach as compared to 2.2% rate for both the anterolateral and transtrochanteric approach. Hematoma formation was significantly higher in the transtrochanteric approach. More importantly, Trendelenburg limp following surgery occured in 10% of the patients in the anterolateral and transtrochanteric groups. Limp occured in 0% of the patients following posterior approach in which the abductor mechanism was not disturbed. Roberts and associates compared the anterolateral approach to the posterior approach in 175 primary THR's using cement [15]. The mean operative time was twice as long in the anterolateral approach (140 min *vs* 62 min), with nearly twice as much blood loss (767 milliliter *vs* 433 milliliter). The length of hospital stay was approximately the same for both groups (15 days *vs* 13 days).

The authors' anterior approach utilizes the interval between the tensor faciae lata and the sartorius. It is more medial than the anterolateral approach used by many others. The abductor mechanism is not released, retracted, or distorted in anyway. This feature of the surgical technique certainly contributes significantly to the fast post-operative rehabilitation in our patients. Furthermore, our mean operative time was 71 min for primary surgery with an estimated blood loss of 375 milliliters. It is important to note that blood loss is generally greater when non-cemented prostheses are used. Our limited soft tissue dissection and relatively short operative time both contributed to comparable blood loss to previously reported series of THR's using cemented prostheses.

The major complication that is more frequent when using non-cemented implants than using cemented prostheses is fracture of the proximal femur. Marchetti and associates reported their first 100 consecutive primary THR's performed using non-cemented prostheses using an anterolateral approach [16]. Femoral fractures and wound hematoma each occured in 4% of the patients. Geesink reported 10% incidence of intraoperative proximal femoral fractures, 3% dislocation, and 2% infection in 100 primary THR's performed using the posterior approach with non-cemented, hydroxyapatite-coated implants [17]. Schwartz and colleagues reported 3% incidence of femoral fractures in a large series of 1,318 THR's using non-cemented prostheses performed by a single surgeon [18].

Although minor peritrochanteric fractures occured in some of our patients, they did not adversely affect the patient's clinical outcome, or more importantly, the fixation status of the femoral stem. We have developed a technique using an oblique femoral osteotomy as an adjunct to difficult revision cases, in order to minimize shaft perforations and fractures. Clinical and radiographic results with the oblique femoral osteotomy and non-cemented prostheses have been very encouraging at medium-term follow-up [19].

It is of importance to note that the incidence of deep infection in our series was only 0.2% in the primary cases. We believe the limited soft tissue dissection, short surgical time required with this approach, the use of prophylactic antibiotics, and avoidance of methylmethacrylate all contributed to this satisfactory result.

Another important feature in this series of patients was that clinically significant thromboembolic disease occured in only 0.7% of the primary, and 1.3% of the revision cases. Venous thromboembolic disease remains the most frequent and potentially fatal complication following THR. The incidence of deep vein thrombosis has been documented to be between 5% and 60% in several large series of patients using a variety of prophylactic regimens [20, 21, 22]. A major contributory factor in the pathogenesis of thromboembolic disease in THR is intraoperative mechanical distortion of the femoral vein due to retraction and leg positioning. This is especially pronounced in the posterior approach [23, 24]. In seperate cadaveric studies, Binns and Pho [23], and Planes and colleagues [25] consistently demonstrated complete occlusion of the femoral vein using the posterior approach. Distortion and occlusion of flow of the femoral vein was rare using the anterior or anterolateral approach. External rotation of the femur in particular, had absolutely no adverse effect on femoral venous blood flow. The leg is only externally rotated without concomitant adduction or flexion during femoral preparation using the authors' surgical approach. This undoubtedly contributed significantly to our clinical success.

Our patients routinely received low-dose aspirin (650 mg per day) for prophylaxis. Aspirin is safe, easily instititued, effective, and inexpensive. We believe that our anterior approach is extremely advantageous in minimizing thromboembolic disease in THR. This approach puts the femoral venous system at minimal risk of occlusion, stasis, and mechanical trauma, as compared to the more popular posterior approach. We believe that the surgical approach coupled with early aggressive postoperative mobilization have been the most important factors in achieving the very low rate of clinically significant thromboembolic disease in our patients while using only asprin.

The anterior approach to THR as developed by the senior surgeon has been applied to nearly 3,000 hips. It is facile in exposure and closure. It provides the surgeon with an anatomic view of the acetabulum which facilitates proper positioning of the cup. The femoral exposure is easy, provided sufficient soft tissue releases are adequately performed. We have modified the approach to maximize our ability to use various non-cemented prosthesis systems over the past decade. The average operative time is less than 90 min, including revision surgery. This approach minimizes trauma to the soft tissues about the hip joint which provides faster postoperative mobilization and rehabilitation. This is evident in that the average length of hospital stay was only 7.3 days after surgery. Our complication rate was no greater than that reported in other series using non-cemented prostheses, both for primary and revision surgery.

We continue to use the anterior approach for all our THR's. Although significant controversy remains whether non-cemented prostheses are superior to cemented implants, we strongly believe that they offer an excellent alternative in selected cases.

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